WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 62

TAFO, GHANA.

PRINTED BY THE HAG PRESS—PRINTERS, TAFO.

30 NOV 1961

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SIXTY-SECOND QUARTERLY REPORT

APIRL - JUNE, 1961

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in WACRI Technical Bulletins and elsewhere.

SENIOR STAFF

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Accountant	J.N.A. Hyde (Ag. Secretary from 22/2/61)
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	B.M. Gerard
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Division of Pathology	J.W. Blencowe (Ag. Director)
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	E.A.T. Asante (promoted A.E.O. 1/4/61)
Division of Chemistry	R.H. Kenten
	D.K. Acquaye
	G.S. Akrofi (promoted A.E.O. 1/4/61)
Division of Agronomy	T.H.R. Hall (returned from leave 23/4/61
	R.W. Smith (on leave 26/4/61)
Statistician	C. de Jonge (on leave)
Spectrographic Specialist	J.C. Burridge (on leave 19/5/61)
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Medical Officer	P.K.K. Knudsen (on leave 1/6/61)
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Secretary	H.L. Pugh (on leave 25/6/61)
Entomologists	R.G. Donald
	P.F. Entwistle (on leave 8/5/61)
	C.K.H. Martini (on leave prior to resignation)
Agronomists	J.F. Longworth (on leave 6/4/61
	G.H. Freeman
	M. Wessel
Mycologist	E.C. Hislop (on leave)
Plant Physiologist	N.I.C. Nwachuku (appointed 22/3/61)
Plantations Officer	W. Rides

ADMINISTRATION

STAFF MATTERS

Messrs. E.C. Boafo, N.K. Lovi, J.K. Bonney, E.A.T. Asante and G.S. Akrofi, formerly Senior Technical Assistants have been promoted Assistant Experimental Officers with effect from 1st April, 1961.

Mr. T.H.R. Hall returned from leave on 23rd April, 1961, and Messrs. R.W. Smith and J.C. Burridge proceeded on leave on 26th April, 1961, and 19th May, 1961, respectively. Dr. P.K.K. Knudsen proceeded on leave on 1st June, 1961 and Messrs. J.F. Longworth, P.F. Entwistle and H.L. Pugh of Ibadan Station proceeded on leave on 6th April, 1961, 8th May, 1961 and 25th June, 1961, respectively.

Mr. N.I.C. Nwachuku, Plant Physiologist, joined the staff of the Ibadan Station on 23rd March, 1961.

VISITORS

The Institute was honoured by a visit in June from Viscount Head, U.K. High Commissioner in Nigeria and Lady Head, accompanied by the U.K. High Commissioner to Ghana and Lady Snelling and Lord Royston. Two parties of delegates to the F.A.O. Conference in Accra visited the Station in April, and other visitors during the quarter included Trade Missions from Hungary, Italy and Russia, Dr. H. Roberts of W.A.I.B.R.U., Mr. P. Allan Jones, Mr. Martin Ormond and Mr. and Mrs.H.G. Llewellyn, all of Shell Co., Ltd.; Mr. J.S. Robertson, Plant Pathologist, W.A.I.F.O.R., Dr. Gladys M. Hickman of the University College of Ghana, Dr. S.D. Garrett, Reader in Mycology, University of Cambridge, Brigadier S.J.A. Otu of the Ghana Army, Dr. F.W. Hauck of F.A.O., Lome. Dr. J. Downing and Dr. F. Baranyovits of I.C.I. Plant Protection Ltd., spent some weeks in West Africa to test chemical spray materials.

Visitors to Ibadan have included Dr. K. Lawton, University of Nigeria, Nsukka, His Excellency the Netherlands Ambassador, Dr. L. Noe, a Chinese Trade delegation, and the F.A.O. Economic Mission to Nigeria.

GAMBARI EXPERIMENTAL STATION

Encouraging progress has been made with the development of this area. The old buildings and labour lines taken over from the Western Region Ministry of Agriculture have been renovated and made habitable. Plans for the new buildings have been drawn up and the building programme has been advertised and tenders invited. Approximately 16 acres of secondary forest has been clear-felled and work is proceeding on a further 8 acres. The planting of Amazon cocoa seedlings is making good progress. Five acres of land for planting Amelonado cocoa is being cleared.

The Plantation Manager at Tafo, Mr. H.W.S. Allison, spent several weeks re-organising the labour system. His visit was extremely helpful and the organisation has been much more efficient and flexible as a result of his advice.

AGRONOMY AND PLANTATION MANAGEMENT DIVISIONS

OLD STATION FARM

YIELD

The number of yield-recorded plots on the Old Station has been increased from 22 to 32. The yields of these thirty-two quarter-acre plots are given in the table below.

TABLE 1

Plots	Total Pods	Diseased	Percentage	Healthy Pods
Tree Recorded (5)	461	24	5.2	437
Plot Record (27)	2,374	261	10.9	2,113
TOTAL (32)	2,835	285	10.1	2,550

The gross yields from the Old Station are given in table 2.

TABLE 2

Period	Amelonado	Amazon	Trinitario	Hybrids	Mature Cocoa	Total
April	487	160	-	-	1,009	1,656
May	66	303	-	-	1,007	1,376
June	251	-	-	-	473	724
Total	804	463	-	-	2,489	3,756

SQUARE MILE

YIELD

The gross yields of pods harvested from non-experimental cocoa in the Square Mile are given in Table 3.

MAINTENANCE OF MATURE COCOA

Routine fertilizer application in experimental areas was completed by the end of May.

The yields from mature experimental cocoa are given in Table 4. It will be observed that the overall yield for the quarter is well below that for the same quarter in 1960.

TABLE 3

Period	Young Planted Cocoa				Mature Cocoa	Total Pods
	Amelonado	Amazon	Trinitario	Hybrids		
April	49	604	-	-	-	653
May	1,188	539	-	1,250	1,812	4,789
June	1,002	-	-	-	146	1,148
Total	2,239	1,143	-	1,250	1,958	6,590

The substantial drop in yield is attributable to the extremely dry conditions which prevailed over the first five months of the year.

TABLE 4

No.	Plot	Experiment	June Quarter 1961	June Quarter 1960
1	B2	U.A. Spacing and Pruning	5,127	23,205
2	B2(a)	U.A. " Extension	1,867	5,942
3	B1	U.A. Multiplication	7,150	21,708
4	J1	Amelonado Spacing Trial	4,687	42,691
5	G5	Amazon Factorial Fertilizer Trial	14,312	15,945
6	H1 & L2	2nd Establishment Trial	8,495	12,239
7	G1	Uniformity Trial	15,213	39,598
8	P2	Amelonado Pruning Trial	1,038	1,742
9	G4	Amelonado Source Trial	2,283	3,381
10	K1	Amelonado Shade and Manurial Trial	9,522	23,604
11	A4	Comparison of Virus Strains	597	1,884
12	A6	Cover Crop and Fertilizer	5,454	7,060
13	H2	Virus on Amazon Cocoa	1,299	3,154
14	H3	" " Amelonado Cocoa	417	1,795
15	P1	Early Bearing Experiment	2,483	5,329
Total			79,944	209,277

MAINTENANCE OF YOUNG COCOA

With the onset of the rains in June, replacements of deaths of Tree Cassava, Terminalia ivorensis and cocoa were effected in last year's planting areas, and some shade reduction was done. The area of clonal cocoa being used for management studies was weeded continuously and mulch of plantain trash applied. Despite this, losses were quite high during the severe and prolonged dry weather. Deaths were replaced in June.

Experimental areas planted in 1959 are now yielding small quantities of pods as shown in Table 5.

TABLE 5

Plot	Experiment	June Quarter 1961
D7	Amazon Tree Forming Experiment	1,416
A3	Clonal Collections	1,439
E1(a)	Shade Efficiency Trial	127
E1	Variety Trial - Virus Resistance	159
K2 & O1	Amazon Shade and Manurial Trial	1,676
-	T O T A L	4,817

NEW PLANTINGS

Preparations proceeded for planting the second block of the Hybrid Shade and Manurial Trial.

BLACK POD RESISTANCE TRIAL - OBOMENG

The 51 seedlings which died during the dry season were replaced during the quarter. The planting of the second batch of varieties was completed by the end of the first week of June. Tree Cassava shade was thinned as required, while Terminalia ivorensis was pruned to one leader.

TREE MORTALITY

Losses of cocoa trees due to swollen shoot virus and other causes in both the Old Station Farm and the Square Mile are given in the table below.

TABLE 6

Month	New out-breaks	COCOA DESTROYED				Dead Undia-gnosed	Infected Total Cocoa removed
		Infected in New out-breaks	Infected in old out-breaks	Infected cocoa seedlings	Contact cocoa trees removed		
April	2	4	17	18	5	-	39
May	1	1	16	10	6	2	27
June	2	3	8	31	30	-	42
Total	5	8	41	59	41	2	108

PROPAGATION

The reconstruction of the propagators was completed during the quarter and observations on the rooting-potential of various W.A.C.R.I. Clones commenced.

DISTRIBUTION OF PLANTING MATERIAL

Twenty-two thousand Amazon pods were purchased by W.A.C.R.I. employees during the quarter.

METEOROLOGY

The aggregate rainfall for April and May was the lowest recorded at Tafo. By contrast, it was the wettest June ever recorded. On June 14th, 4.86 in. fell within the 24-hour period. The data are presented in Table 7.

TABLE 7

Month	1961		Past 23-year means	
	Rainfall (ins)	Wet days	Rainfall (ins)	Wet days
April	2.95	10	6.27	11.4
May	3.83	9	7.40	13.9
June	16.46	23	8.91	18.9

EXTENSION WORK

The clearing of 18 acres of Block A was completed for planting this year. Ten acres of Block C was planted with beans "at stake".

Vacancies in Plots C1, C3, E2, Q1 and 35 Acre Block were replanted.

PATHOLOGY DIVISION

VIRUS RESEARCH

MECHANICAL TRANSMISSION OF COCOA VIRUSES

Properties of Cocoa Swollen Shoot Virus

With the New Juaben and Bosomuoso isolates of CSSV, the infectivity of slurries prepared from infected Adansonia digitata and Bombax brevicuspe increased after storage for 24 hr. at 0-4°C (Table 8) and in two experiments was retained after storage at 36°C for three hours. Infectivity has been demonstrated in precipitates which separate from extracts of B. brevicuspe when half-saturated with ammonium sulphate. These results indicate that, like the Nigerian viruses, some of those occurring in Ghana should be sufficiently stable in vitro to permit purification in the ultracentrifuge.

TABLE 8

Plant Species	Virus	Infectivity	
		Fresh	After 24 hours.
Bombax brevicuspe	Bosomuoso	3/98	4/99
Bombax brevicuspe	Bosomuoso	1/95	4/97
Bombax brevicuspe	New Juaben	0/99	1/97
Adansonia digitata	New Juaben	1/100	6/100
Adansonia digitata	New Juaben	0/93	3/73
Total		5/485	18/458

Table 8: Effect of keeping inocula at 0-4°C for 24 hours.

It is not clear why the infectivity should increase under these conditions but it has been reported that extracts from plants infected with the Rothamsted Tobacco Necrosis Virus become more infective when stored in the refrigerator (Bawden, F.C. & Pirie, N.W. 1950. J. gen. Microbiol. 4, pp.464-481).

EFFECT OF VIRUS INFECTION ON GROWTH AND YIELD OF AMAZON AND AMELONADO COCOA

In experiment H2/3 (Quarterly Reports 57 and 58) all the graft-inoculated Amelonado trees became visibly infected within 20 months; by contrast, only 80 per cent. of the Amazon trees had produced symptoms within 2 years of graft-inoculation. The

Amazon trees which have not yet shown symptoms have been back-tested by patch-grafting healthy Amelonado seedlings. In experiment A4 all trees graft-infected with the virulent viruses produced symptoms within 2 years although swellings have not yet been detected on 4 per cent. of the trees infected with the mild Worawora isolate.

An analysis of the 2 years' yield data for experiment A4 has shown that in the second year of infection the Kpeve isolate had reduced yield by 64 per cent., the New Juaben by 44 per cent., the Dawa by 31 per cent. and the Bosomuoso isolate by 19 per cent. The Worawora isolate had no significant effect on yield. In experiment H2/3 the New Juaben isolate greatly reduced the yield of fertilised and unfertilised Amelonado trees on both shaded and unshaded plots. On Amazon cocoa the overall responses to virus infection and applications of fertiliser are not statistically significant. However, it would appear that there is an interaction between these two factors and that virus-infection has caused a yield reduction of about 30 per cent. when the trees were not receiving additional fertiliser. Six different Amazon types are represented in this experiment; type T17 has been least damaged by virus infection.

Complete control of capsids was achieved by spraying both experimental areas with gamma B.H.C. in June, July, November and December at the rate of 2 oz. insecticide per acre. The deterioration of the canopy of Amelonado trees infected with the severe viruses in experiment A4 has continued and 4 per cent. of the trees have died. The canopies of the infected Amazon trees in experiment H2/3 have been slightly affected but, as in experiment A4, those of Amelonado trees have continued to deteriorate.

BLACK POD DISEASE

MECHANISMS OF RESISTANCE AND TOLERANCE TO PHYTOPHTHORA PALMIVORA

Work has continued on quantitative evaluation of the polyphenoloxidase activity of acetone extracted powders from tissues of cocoa selections showing apparent differences in susceptibility to Phytophthora pod rot. Acetone extracted powders of the enzyme have been prepared from cherelles and internal and external endocarp tissues of large immature and ripe pods by slicing the tissue directly into 80 ml. of acetone, macerating for 1 min., and washing four times in 40 ml. of acetone

with a final wash in 40 ml. of ether. The air-dried powders were then finely ground in a mill and stored at approximately 6°C. The enzyme activity of each powder was tested by addition to 10 ml. of 0.1M citric acid buffer at pH 6.0 containing 25 mgm. of pyrogallol. After 10, 20, 30 and 40 minutes, 10 ml. of the bulk solution were removed, the reaction stopped with hydrochloric acid and the solution centrifuged to remove suspended mucilage and particles. Optical density (OD) of the supernatant was measured by an EEL absorptiometer, using filter 601. From these readings, rates of enzyme activity were calculated.

With a few cocoa selections remaining to be tested, no significant differences in activity have been found between 'resistant', 'intermediate' and 'susceptible' groups of selections, although a wide variation was found in enzyme activity of powders from different individual selections, particularly between older tissues. The results, summarised in Table 9, showed that polyphenoloxidase activity was invariably greatest in cherelle tissue powders; in large immature and ripe pods activity was usually higher in external endocarp tissues. The results suggest that if polyphenols are contributory to resistance to infection, the decisive factor is unlikely to be the level of oxidative enzyme.

TABLE 9

	Cocoa Selection	Cherelle	Large Immature E.E.	Large Immature I.E.	Ripe E.E.	Ripe I.E.
'Resistant'	D70	15	18	24	NT	NT
	Y44	25	37	38	36	41
	U6	20	21	24	30	31
	S27	25	24	32	23	25
	ACU85	11	26	30	30	28
	Mean	19	25	30	30	31
'Intermediate'	P30	16	31	32	43	41
	E1	20	19	23	45	80
	ICS1	23	30	34	NT	NT
	02	22	26	34	37	41
	B1	19	34	37	NT	NT
	Mean	20	28	32	42	54
'Susceptible'	TF2	20	34	31	NT	NT
	A56	21	33	43	25	23
	A12	18	20	28	19	24
	A62	19	39	38	29	34
	R15	17	29	32	NT	NT
	Mean	19	31	34	24	27
Unselected Amelonado		17	17	18	28	36

E.E. = External endocarp pod tissue. I.E. = Internal endocarp pod tissue.
N.T. = Not tested.

TABLE 9: Polyphenoloxidase activity of acetone powders, from ten pods of each selection, expressed as the mean time taken to reach an increase of 15 OD with filter 601.

GALL DISEASE

Calonectria rigidiuscula has now been isolated from 7 galls on trees and from four produced on seedlings after inoculation of half-beans with macerated tree-gall tissue. Pure cultures of each isolate have induced galls on cocoa seedlings grown

TABLE 10

Isolate	Origin	Transmission rates	
		In separate tests	Total
B84	Tree gall	4/5 3/4 4/5	11/14
B86	Tree gall	5/5 3/5 4/4	12/14
B87	Tree gall	4/5 2/4 4/5	10/14
A103	Tree gall	4/5 5/5	9/10
A106	Tree gall	4/4	4/4
A108	Tree gall	5/5 4/4	9/9
A109	Tree gall	4/4 4/5 3/4	11/13
B75	Seedling gall	5/5 5/5 5/5 5/5 5/5 5/5 10/10 5/5 10/10	55/55
B85	Seedling gall	4/4	4/4
B151	Seedling gall	4/4 5/5 10/10 5/10 5/5 10/10 10/10 7/9 10/10 4/6 10/10 10/10 5/8 6/9	101/116
B151*	Seedling gall	5/5 6/9 5/5 15/18 10/10 5/5 5/5 5/5	56/62
B157	Seedling gall	9/10 4/5	13/15
B75#	Seedling gall	2/3 4/4 9/10 5/5 4/5 4/5 5/5 3/4 5/5 3/4 4/5	48/55
B84#	Seedling gall	4/5 5/5 5/5	14/15
B86#	Seedling gall	3/5 4/4 4/4 5/5	16/18
B87#	Seedling gall	4/4 4/5 5/5 5/5	18/19
B151#	Seedling gall	3/3 5/5 5/5	13/13
B157#	Seedling gall	4/4 4/4	8/8
		Total	412/458
7 isolates B282 & B283,613 to 617	Dieback tissue	All negative (22)	0/190

*Data from 3 single spore sub-cultures.

#Data from re-isolates.

TABLE 10: Infectivity of C. rigidiuscula isolates

(Numerator indicates the number of plants with galls and the denominator the number of test beans inoculated).

from inoculated half-beans (Table 10) and one culture (B151) has induced galls on 2 inoculated pod stalks and 11 flower cushions of mature trees. The fungus has been recovered from one or more galls on test plants inoculated with 6 of the isolates and the re-isolates again shown to be infective.

Table 10 shows the high infectivity of all these isolates to beans of West African Amelonado cocoa. The table incorporates results from a number of transmission experiments in which aqueous suspensions of conidia and mycelia of the isolates were applied to half-beans with small, sterile paint brushes soaked in the inoculum. The brushes were always tested for sterility by first brushing 5-10 control half-beans with sterile water; galls never developed on the control seedlings which were grown alongside treated beans in the same seed boxes.

In Ghana C. rigidiuscula is commonly found infecting debilitated cocoa. Five additional isolates of the fungus from such material on trees free from galls (cf. Quarterly Report No.60) did not cause gall formation in any of the seedlings inoculated as beans (Table 10).

ENTOMOLOGY DIVISION

CAPSID STUDIES

JOINT WACRI/DIVISION OF AGRICULTURE CAPSID CONTROL TRIALS

Application of Lebaycid (S.1752) 50% E.C. at 45 ccs. actual in 5 gallons of water per acre gave good control of capsids following applications in January and February. This insecticide is the first organo-phosphorus compound tested in the field in Ghana which has given satisfactory capsid control at rates economically comparable with chlorinated hydrocarbon insecticides. The trial is being extended and application of Lebaycid will be made to five plots as a 50 ccs. actual and a 100 ccs. actual application in both June and July. A Gammalin 20 treatment is being maintained to act as a standard for comparison. One pound actual Dipterex as the 80% Soluble Powder gave more effective control than the previous Sevin treatments but was less effective than Lebaycid and was discontinued.

MEALYBUG STUDIES

JOINT WACRI/DIVISION OF AGRICULTURE ANT/MEALYBUG CONTROL TRIALS

A gradual rise in ant and mealybug populations has occurred on all plots throughout the quarter. Minor pest activity is

minimal.

CHLORDANE AND HEPTACHLOR TRIAL

Populations of both ants and mealybugs have fallen following the applications of insecticide in February and March. No marked increases in minor pest populations are yet apparent.

ANT/MEALYBUG POPULATION STUDIES

The Ant/Mealybug survey under different conditions of cocoa establishment continues.

Table (11) shows the total number of times the various species of attendant ants have been recorded from 5,760 trees in sixteen months.

From the figures given in the table it would appear that the removal of timber depresses the population of Crematogasterine ants but has little effect on the Camponotine ants. The type of shade provided and the amount of inter-row vegetation also appears to influence the ant populations.

TABLE 11

Plot.	Cultural conditions	Number of times recorded			
		Crematogaster Spp.	Camponotus Spp.	Pheidole Spp.	Tapinoma Spp.
H4	Timber left	1,060	1,484	222	28
E1	"	1,713	880	76	282
K2	Timber removed	550	1,800	49	144
N9	"	87	2,731	24	40
Total		3,410	6,895	371	494

RADIO-ISOTOPE STUDIES

SYSTEMIC INSECTICIDES

The work on Dimethoate (Rogor) labelled with radioactive P35, first reported in Quarterly Report No.57, has been continued and extended to determine its uptake, movement and evenness of distribution in 3 year old and mature cocoa. Application was made by trunk injection, trunk implantation and soil watering. Similar treatments were also made with 'tagged' orthophosphoric acid. Measurements of radio-activity have been carried out for bark plus phloem, xylem, leaf, and pod samples. Separation of actual dimethoate from its metabolites has been made to determine persistence and breakdown in the tree over a period of days. The results of this experiment will be reported in detail else-

where.

POLLINATION STUDIES

From 3rd April 1961 detailed records of flowering and setting (which is a practical measurement of successful pollination) have been taken for the trunks of 207 trees in plot D1. This plot consists of about 8 acres of 9-year old Amelonado cocoa.

The opening and setting (as indicated by enlargement of the ovary) of all flowers on trunks between 1-6 feet above soil level is marked daily and the development of each flower which sets is followed. Soft wire, permanently fixed to each tree, divides the trunk into foot sections between 1-6 feet and into north and south giving 10 approximately equal-sized areas for each trunk.

The data obtained will be used primarily to provide detailed performances of individual trees which can be compared with the performances of the same trees under insecticidal treatments (i.e. pre-treatment data). More detailed information may also be obtained, e.g. on the distribution of flowers, the relationship between flower position and setting, and on the vertical distribution of mature pods.

MINOR PESTS

MARMARA STUDIES

Monthly surveys were carried out in each Block of the Square Mile to assess the extent of damage by Marmara to pods, chupons and the canopy. It was found that the highest damage was centred around H Block. It has been observed previously (Rep. W. Afr. Cocoa Res.Inst., 1957-58) that the incidence of high Marmara populations is somehow related to the application of dieldrin. Two plots viz. H2/3 (described in Rep. W.Afr. Cocoa Res. Inst., 1959-60) have been sprayed with dieldrin twice each June and December at the rate of 16 oz dieldrin/acre at each application since 1960 (in addition to Rogor and gamma-BHC). A more detailed survey which has been started in H2/3 and a few selected plots is designed to emphasize any differences between Marmara populations and also any differences that may exist in the habitats apart from the insecticidal treatments.

Adult specimens have been obtained from mined pods collected from most non-experimental parts of the Square Mile. There are no obvious differences between any of the specimens suggesting that there is only one species but a taxonomic study

of the genitalia will be necessary before this can be confirmed. The decoration on all pupal cocoons seen so far has been similar, which substantiates the suggestion that the "cocoa pod-husk miner" at Tafo is a single species.

Assuming that a single species was involved records were taken in D1 using several methods to assess the population numbers of all stages and fluctuations. New suction traps are being made to enable the direct estimation of the adult population

General Studies:

General collections of the arthropod fauna of cocoa plantations have been started so that a general picture can be obtained of the ecological relationship of the taxa in this community. Later more specific information may be obtained on the herbivore-plant, predator-prey and parasite-host interactions. This information might be used to detect the reasons for increase in minor pests following application of certain insecticides and also to discover potential pests.

LEPIDOPTERA STUDIES

Leaf-eating lepidoptera

Routine collecting and rearing of lepidopterous larvae found on cocoa is continuing. A further collection of lepidoptera and their parasites has recently been sent to the Commonwealth Institute of Entomology for identification. A collection of photographs of lepidopterous larvae is being made.

BOTANY DIVISION

PLANT BREEDING

OBSERVATIONS ON POLLINATION AND FRUIT SETTING IN A LARGE PLOT OF A SELF-INCOMPATIBLE CLONE

Observations on pollination and fruit-setting etc., are in progress in the E1 plot at Bunso. This is an isolated block of 5 acres of a self-incompatible clone, which has yielded about 600 lbs of cocoa per acre in recent years. A crop is obtained over the whole area, and not only from the part of the plot nearest to other cocoa.

Studies are centred mainly on 24 selected trees scattered over the plot. These were first tested for self-incompatibility; when 300 self-pollinations were made only four fruit appeared to set, and three of these subsequently fell. Flowering and natural fruit-setting are being recorded on these trees; flowering has been intense since May, but setting is as yet very

slight. Examination of samples of flowers collected from the trees has shown that an average of about 8% of flowers had been pollinated.

On two trees 310 flowers were hand-pollinated with Amelonado pollen, which is compatible with the E1 clone. Two hundred-and-twenty-four of these flowers set fruit, and most of them are still on the trees.

It has previously been assumed that all natural setting in this plot has been due to pollen from outside the plot, and it was thought that these observations would give information on the frequency of such long-distance transport of pollen. However the fruit-setting observed to date, averaging about 7 cherelles per tree, could possibly have been due to a very small proportion of self-pollinations, one in 300 or less, having resulted in fruit setting.

QUALITY ASSESSMENTS OF SOME VARIETIES BY AMERICAN FIRMS

Reports from the American chocolate manufacturers on cocoa samples submitted early in 1960 have now been received, and in general are satisfactory. The mean scores given to the series as a whole ranged, for the five firms, from 6.3 to 8.7 (on a 0 - 10 scale). Two samples of Amelonado were included in the series; the relatively slight differences between the scores accorded to the different varieties by individual firms suggested that they did not find any substantial differences between the varieties or between the varieties and Amelonado.

Analysis of variance and ranking tests showed that there was no overall agreement between the firms as to which samples were best. There was however a significant degree of concordance between three of the five manufacturers, a fourth was in partial agreement with the first three, while the fifth seemed to have quite different preferences. Although none of the samples was very distinct from Amelonado, it was possible to get some indication as to which samples were closest to Amelonado in flavour.

PLANT PHYSIOLOGY

MINERAL NUTRITION

The first sand culture experiment was started in the greenhouse, which was completed during the previous quarter. The purpose of this experiment was to determine the growth effects on plants grown in conditions of macronutrient deficiency of N, P, K, Ca, Mg or S or excess of N or P. Half

of the plants were infected with the New Juaben strain of swollen shoot virus before planting.

The first groups of seedlings were harvested 65 days after planting. On the basis of plant dry-weight, the virus-infected plants were 66.4 per cent of the non-infected plants. The greatest reduction caused by virus-infection was in leaf dry weight.

Only plants in the low Mg treatment showed deficiency symptoms at the time of this harvest but the dry-weights of plants receiving a low level of Ca, or Mg or a high level of N were significantly less than the control. There was no interaction plant dry-weight between virus and nutrient effects.

The percentage water in leaf, stem and roots did not vary between virus-infected and non-infected plants.

At the time of the first harvest plant height and leaf area differed significantly only between virus treatments. The height of the virus infected plants was 88.9 per cent of the non-infected plants indicating that the plants with virus were fairly tall but spindly (cf. plant dry weight).

Chemical analysis of the harvested plants is now in progress.

Preparations are now complete for the commencement of a large scale micronutrient experiment.

CHEMISTRY DIVISION

SOIL FERTILITY

FIELD EXPERIMENTS

Amelonado Shade and Fertilizer Trial

The severe drought which occurred during the quarter has reduced the yields on this trial. In Table 12 it will be seen that, although the shade and fertilizer effects still remain only about 38 per cent of the yield was obtained when compared with the same period in 1960.

TABLE 12

Treatment	Non-irrigated			Irrigated		
	1960(A)	1961(B)	$\frac{B}{A}$ x 100%	1960(A)	1961(B)	$\frac{B}{A}$ x100%
Shade No Fertilizer	483	453	93.79	272	266	97.79
Shade Fertilizer	1,318	1,260	95.60	500	520	104.00
No Shade No Fertilizer	5,142	1,196	23.26	2,211	1,062	48.03
No Shade Fertilizer	6,329	2,120	33.50	3,066	1,786	58.25
Total	13,272	5,029	37.89	6,049	3,634	60.09

Table 12: Comparison of yields for the period March-June 1960 and 1961 (Total number of pods).

On the irrigated plots, about 60 per cent of last year's yield was obtained. The yield reduction on the shaded, non-irrigated plots was small (ca. 4-6 per cent) compared with the unshaded non-irrigated plots (ca. 67-77 per cent). This appears to suggest that the previous differences in yield between shaded and un-shaded cocoa might largely have been due to competition for nutrients rather than for water; the water effect appears to be due mainly to difference in evapo-transpiration caused by difference in insolation. This conclusion is borne out by the yields on the irrigated plots; whereas the effect of the drought is almost offset by irrigation in the shaded plots, irrigation only brought the yields of the unshaded plots up to about 50 per cent.

The trees are now flushing heavily and it remains to be seen whether the yield will catch up following the heavy rains of the latter part of the quarter.

Cover Crops Experiment (H5)

The cocoa on the cover crops experiment (H5) was thinned to 8' x 8'. Two trees each from the eight treatments were excavated and stem and root measurements were taken. No additional important information with regard to the comparative effects of the different treatments was obtained. (See Cunningham R.K. and Smith R.W., 1961, Trop. Agric., Trin. 38 pp. 13-22).

Amazon Shade and Fertilizer Trial (K2 - 01)

Concrete marker posts were placed in the field and all the plots were labelled with the treatment codes and the plot numbers. The Agronomy Division commenced harvesting and pre-treatment plot totals are being taken. The trees are beginning to recover from the effects of the severe dry season of last quarter and have flushed quite heavily.

Joint WACRI/Cocoa Division Trials

The records for these experiments have been received and analysed statistically. The treatment effects have been summarised in the Annual Report 1960-61.

All the plots received their fertilizer applications in April as usual.

New Experiments

The proposed four new experiments (Quarterly Reports 60 and 61) on Cocoa Division Stations designed to investigate nitrogen and phosphorus responses were laid down and fertilizers

applied in April. Pretreatment records were received for the seasons 1959/60 and 60/61 from three of the stations - Akaa, Biene and Kwadaso and are being summarised.

At Tafo two new experiments (D11 and D12) have been planted. They are designed to determine the effect of fertilizer application on cocoa at the time of planting and in the early years of growth. Plot D11 has been planted with temporary shade of tree cassava.

Irrigation Trials H4(a) and K1

Recording of moisture by nylon units was discontinued in H4(a) and the units removed to supplement those in plot K1. In K1 the irrigated plots continued to give more flowers than the non-irrigated plots.

LABORATORY STUDIES

The soil phosphorus studies described in the previous Quarterly Reports 60 and 61 have continued. Whereas no mineralisation of organic-P occurred on incubation for up to 28 days at a laboratory temperature of about 27°C and 50 per cent water holding capacity, the extended period of incubation has resulted in a small amount of mineralisation at 42, 56 and 70 days incubation. Addition of nitrogen at two levels (0.1g and 0.2g N as urea) and phosphorus (0.1g and 0.2g P_2O_5 as triple superphosphate) separately to 50 g. of soil resulted in marked increase in mineralisation of organic-P at room temperature during 14 and 28 days incubation. The addition of phosphorus caused higher mineralisation in some soils and in other lower mineralisation than did the addition of nitrogen. Mineralisation was generally higher at 28 days than at 14 days of incubation, and slightly higher at the higher levels of both nitrogen and phosphorus. Incubation for 14 days at 40°C and 50 per cent water holding capacity has resulted in about the same degree of mineralisation as when nitrogen was added. Incubations are being carried out at 50°C to see whether further increase in mineralisation will occur.

The results obtained so far can be summarised as follows:

(1) Generally more than 50 per cent of the total phosphorus in the soils is present in the organic form.

(2) The organic-P content of both the incubated and non-incubated samples was closely correlated with the percentage total-N, percentage organic-C, pH and total-P. The total-P was also correlated with the percentage total-N, percentage organic-C and pH.

(3) Some mineralisation of the organic-P occurred only after incubation for more than 28 days at laboratory temperature of

about 27°C and 50 per cent water holding capacity. Addition of N as urea and of P as triple superphosphate caused marked mineralisation on incubating for 14 and 28 days. Increase in temperature to 40°C also resulted in mineralisation on 14 days incubation.

It can be concluded from these results that since carbon, nitrogen and phosphorus are associated in the soil organic matter, it is apparent that the relative amounts of these elements in the soil probably determines to a large extent the trend of its mineralisation. A great deal of attention has always been drawn to the mobilisation of phosphorus as iron and aluminium-P in tropical lateritic soils. Although organic matter is usually low in these soils, our results suggest that the organic-P in tropical soils may be more important than has hitherto been appreciated and that factors related to its mineralisation warrant more systematic and detailed studies.

The laboratory investigations on the effect on broadcasting of fertilizers on the thick litter in field experiments (Quarterly Report 60) have been continued, and the former soil exposure experiment site has been planted with six-month-old Amazon T63 seedlings at 4' x 4'; each plot thus containing 3 seedlings.

Laboratory investigations on the various soil series at WACRI commenced last quarter have continued.

Pot Experiment

The pot experiment which was commenced last quarter to compare the effects of two levels of phosphorus (rock or triple-superphosphate) and three levels of nitrogen (urea or sulphate of ammonia) on the growth of and uptake of native micro-nutrient by young cocoa seedlings entered its third month.

The treatments of the experiment, which involved three different cocoa soils of pH's 7.05, 6.35 and 5.80, were completely randomised in eight concrete tanks. Each pot contained 7 kg. of soil and the first application of fertilizer which consisted of nitrogen at 0.1g, 0.2g and 0.4g and phosphorus at 1g and 3g, P_2O_5 in all possible combinations was made at the time of sowing. Four beans per pot were sown. In the fourth week the seedlings were thinned down to one per pot and the second application of fertilizer at the same rates was made. Fortnightly height measurements were begun in the sixth week.

At the time of writing, a multitude of nutritional disorders, among them sickle-leaf, "paint brush" and necrotic spots or "measles" on the leaves and stems, have appeared.

IBADAN STATION

PLANT PATHOLOGY

The experiments on mechanical transmission of Nigerian cocoa viruses are continuing though progress has been hindered by the delay in the installation of the ultra-centrifuge.

ENTOMOLOGY

SHOT-HOLE BORER STUDIES:

Observations on Shot-hole Borers on Coffee: Since it has been shown that the main cultivated host of the shot-hole borer (Xyleborus morstatti Hag.) in Nigeria is Robusta coffee (Coffea canephora), and that this crop might provide a source of beetles from which cocoa may be infested (see previous Quarterly Progress Reports), investigations have been started to determine the seasonal distribution of breeding activities in a block of regenerating coppiced coffee at Gambari. The block chosen is a narrow rectangle of about 2½ acres, having forest on two adjoining sides, and mature cocoa on the other long side; the fourth side, a short one, had large Robusta coffee trees when observations began in April, but these were coppiced by the staff of the Agricultural Division, Ministry of Agriculture and Natural Resources, Western Nigeria at the end of June, 1961.

The block has been divided into four plots, two of which are adjacent to the cocoa and two near the forest. A systematic sample of 20 trees is examined in each plot at monthly intervals, only the starting point being random. This technique ensures that the trees examined are distributed evenly between rows at different distances from the forest or cocoa. Open and occluded galleries are counted on three pairs of branches from different heights in each tree, one branch from the middle of the tree being removed for more detailed examination in the laboratory. All open galleries in these branches are recorded, notes being taken of the girth of the branch and distance from the base at the point of entry, of the extent of the gallery, and of the presence or absence of X. morstatti in all stages of development.

Only 25 open galleries have been found in the 240 branches examined in detail during the quarter and all of these appeared to be of last seasons origin. No signs of recent shot-hole borer attack were seen on any of the 1440 branches examined

in the field.

Observations on Cocoa Seedlings amongst Coffee: Two groups of eight cocoa seedlings in pots have been sited in each of the four plots described above. These are examined at weekly intervals for shot-hole borer attack and are replaced by fresh seedlings every month. No attacks have been noted during the quarter, but when they do occur the height above soil level and the side of the plant attacked (N.S.E. or W.) will be recorded. At the end of the month the girth of all seedlings is measured and any that have been attacked will be examined in the laboratory, records, similar to those described above for coffee, being taken.

The absence of X. morstatti from both cocoa and Robusta coffee, in an area in which both crops were heavily attacked during the previous year, indicates that breeding during the early months of the wet season probably occurs only on some other host or hosts. No further evidence has been found to suggest what these hosts are, but continued observations on these plots may indicate whether both crops are invaded from wild hosts in the surrounding forest at about the same time, or whether the coffee is attacked first and the spread to cocoa takes place only after the population on coffee has increased considerably.

MINOR PESTS OF COCOA

Observations have continued on the incidence of various minor pests of cocoa on the Gambari Shot-hole Borer Experiment 1.

Lepidopterous larvae, Ferrisiana virgata (Ckll.), other mealybugs, and psyllids have all increased in numbers during the quarter, whereas thrips, spider-mites and scale insects have become less common. Even after allowing for the higher numbers of trees surviving in the shaded plots, numbers of all pests were found to be higher there than on the unshaded plots, though it has not been possible to determine to what extent this may be due to the larger size and more profuse flushing of the shaded trees or to the direct influence of the shade itself upon the insects.

CHEMISTRY

The Soil Chemist visited Cocoa Estates in the Ikom and Umuahia areas at the request of the Eastern Nigeria Development Corporation. The possibilities of joint-experiments are being

investigated.

FERTILIZER TRIALS:

Field Experiments: A new fertilizer trial has been started at Araromi Farm. The treatments are NP, KMg and NPKMg at two levels, plus mulch and control. There are six replications and thirty-six seedlings per plot. Planting of Amazon seedlings took place in the beginning of June at a distance of 5 feet by 5 feet. The first fertilizer application was given three weeks after planting.

At Gambari Experimental Station a fertilizer trial was started in a part of the Amazon Introductions (planted 1944). Four different combinations of N.P.K.Mg. fertilizer are being compared. There are six replicates and sixteen trees in a plot.

Pot Experiments: The same fertilizer combinations as used at Gambari are being compared in a pot experiment.

Zinc Deficiency: The frequent occurrence of zinc-deficiency in the Gambari nursery provided a stimulus to study this disorder. The effects of lowering pH and raising the level of phosphate, iron and zinc are investigated in pot experiments.

The effects of foliar applications of major elements are also being studied in pot experiments.

AGRONOMY

NURSERY TRIALS:

The main nursery trial conducted at Gambari this season and described in the last two Quarterly Reports, was continued. The light shade had become very thin by the middle of April and was then removed, and the heavy shade was left on for a further four weeks and then taken off. With the beginning of the rains, the watering treatments also were omitted when there was sufficient rain. The trial was then transplanted to its permanent position in the field in early June. At this time 4 plants selected at random out of the 24 in each subplot were cut up and examined, and the remaining 20 planted in the field at a spacing of 5 feet by 5 feet in 4 rows of 5 per plot. The plots were re-randomised for field planting, the division into main plots being ignored, and the trial now has one complete guard row round the outside but no internal guards. The soil is being kept bare and, in the dry season, palm fronds will be used to shade the whole area. Leaf number and height records will continue to be taken every four weeks, and girths will be measured

four times a year.

The dry-weight of the sampled plants was found, for leaves, stems and roots separately, and the leaf dry-weight and leaf number were used to give an estimate of the total leaf dry weight of the plot of 24 plants. The results obtained from these measurements, together with height and leaf number at time of transplanting, tend to confirm those given in the last Quarterly Report. All the results lead to the general conclusion that, so far as growth in the nursery is concerned, the biggest plants, in every respect, are those grown under light shade, watering more often than twice a week not being necessary. Some of the plants that were never shaded but were watered every second day also grew well, but this treatment was not equally successful at all times of planting. Over the whole period the plants were in the nursery, only 1.3 per cent of the plants under light shade had to be replaced and 4.7 per cent of those under heavy shade; for the unshaded plants the corresponding figures were 8.9 per cent for those frequently watered and 27.6 per cent for those watered only twice a week.

The trials making use of concrete beds have been less successful, and the method will have to be modified before next season. Some of the plants grown under light shade have however grown quite well and will be planted in the field, together with those sown at the same time under standard conditions.

SHADE OBSERVATION TRIAL:

A trial has been started at Gambari in conjunction with the Soil Chemist to observe the effects of different shading methods on the establishment of cocoa. The use of palm fronds on bamboo supports, though effective on a small scale, is impracticable over a large area, and an alternative method is being sought. It will probably be necessary to conduct a series of trials, and the present one will be regarded as giving preliminary information. It has only two replicates of 100 trees to a plot, the planting distance being 5 feet by 5 feet and the trees being mixed Amazons transplanted from the nursery where they have been since December. Tree cassava, Crotalaria, pigeon pea and plantain are being used as possible shade crops, and there are three forms of inert cover as well as no shade. Apart from the shade crops the soil is being kept bare. The inert cover consists of palm fronds placed round individual trees, and plastic mulch applied in June or October; the plastic mulch consists of strips of black polythene 4'6" wide

laid on the ground between the rows of trees and will not be supplemented by any shade. Since there is some spare land available in the trial area, the opportunity has been taken to sow seed at stake. This has been sown in June and so will be much younger than the transplanted material, but certain general comparisons will be possible.

STATISTICS

The examination of the results of past trials has continued, particular attention being paid to yield records on capsid control trials. The trials to be planted this season at Gambari have all been designed. None exhibits any unusual statistical features, the lay-out being kept as simple as possible. One trial designed for the Federal Department of Agricultural Research, however, had a complex factorial structure, being on an annual crop, and the design was more complicated than could be tolerated on a perennial crop such as cocoa. Advice has also been given to commercial organisations wishing to conduct trials.

SEKA.